



IEEE Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity

IEEE Power Engineering Society

Sponsored by the
Power System Analysis, Computing, and Economics Committee

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Sponsor
Power System Analysis, Computing, and Economics Committee
of the
IEEE Power Engineering Society

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Abstract: This standard provides a methodology for the interpretation of electric generating unit performance data from various systems and to facilitate comparisons among different systems. It also standardizes terminology and indexes for reporting electric generating unit reliability, availability, and productivity performance measures. This standard is intended to aid the electric power industry in reporting and evaluating electric generating unit reliability, availability, and productivity while recognizing the power industry's needs, including marketplace competition. Included are equations for equivalent demand forced outage rate (EFOR_d), newly identified outage states, discussion of commercial availability, energy weighted equations for group performance indexes, definitions of outside management control (OMC), pooling methodologies, and time-based calculations for group performance indexes.

Keywords: available state, EFOR_d, equivalent demand forced outage rate, forced outage, maintenance outage, OMC, outside management control, planned outage, pooling methodology, transition between active states, unavailable state, weighted factor

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Introduction

This introduction is not part of IEEE Std 762-2006, IEEE Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity.

Measures of generating unit performance have been defined, recorded, and utilized by the electric power industry for over 60 years. The increased focus on generating unit performance in a competitive marketplace has caused regulatory agencies and the industry to place a greater emphasis on performance measures.

This standard was developed in 1987, based on efforts started in 1980, to provide terminology and indexes for use in existing data systems or in future systems. The focus of this revision is on performance measures to be used in a competitive marketplace.

Some indexes are based on period hours. By use of such a common base, simple additive relationships between various indexes result, and the use of period hours gives sets of indexes that sum to 100%. Other indexes are not based on period hours. This revision of the standard has included terms for units involved in nonbase load operations. The IEEE 762 Working Group defined sufficient data categories (states, times, capacity levels) so that suitable indexes for all types of units can be calculated.

It should be noted that even the use of all the indexes and terms cannot identify the underlying and sometimes compelling reasons for lost performance.

The IEEE 762 Working Group performed an in-depth review of the concept and practices for commercial availability. The working group unanimously agreed that commercial availability should be studied further, but it should not be a part of this standard. It would be best addressed in a new standard. Efforts for developing such a new standard were judged to be outside the scope of the working group's charge and responsibility.

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IEEE Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity

1. Overview

Although a generating unit generally includes all equipment from the fuel supply system up to the high-voltage terminals of the generator step-up transformer and the station service transformers, any event preventing the ability of the generating unit to produce electricity at its maximum capacity is covered in the scope of this standard. Sometimes, the generating unit cannot provide the power required to the customer because of problems not related to the power plant equipment. Some examples of these “external events” are transmission system failures, labor strikes, and catastrophic storms.

NOTE—See Annex D for a discussion on these external events.¹

Reliability in this standard encompasses measures of the ability of generating units to perform their intended function.

Availability measures are concerned with the fraction of time in which a unit is capable of providing service and accounts for outage frequency and duration.

Productivity measures are concerned with the total power produced by a plant with respect to its potential power production. A plant could comprise a unit or a number of units. Therefore, productivity measures consider magnitude of event as well as frequency and duration of event.

This standard was developed for application at the unit level; it does not address applications at the plant component or system level. Because of these exceptions, care should be taken when using this standard below the unit level.

Many of the performance indexes defined in Clause 8 are expressed as either outage rates or factors, and it is important to note the difference. A factor represents the percentage of time in the period of study that a unit occupied a given state, as in availability factor (AF), forced outage factor (FOF), or service factor. A factor may also represent the percentage of a total outcome achieved, as capacity factor represents the ratio of actual to theoretically possible generation. Factors may be added to provide a total accounting for unit states during a given period.

¹ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement this standard.

By comparison, outage rates provide a measure of the probability, calculated from historical data, of the existence of an outage state any time in the future or under certain conditions.

Attaching the term *equivalent* to any rate or factor, as equivalent availability factor (EAF) or equivalent forced outage rate (EFOR), indicates that both full outages and deratings have been considered in the calculation.

The term demand applied to a rate, as in $EFOR_d$, indicates that the probability of an occurrence has been estimated for periods when the unit is in demand to generate

When statistics are combined for more than one unit, the term *weighted* indicates that data from each unit influence the total in proportion to its size or other indicated weighting factor. See Clause 9 and Clause 10.

1.1 Scope

This document standardizes terminology and indexes for reporting electric generating unit reliability, availability, and productivity performance measures while recognizing the power industry's needs, including marketplace competition. This standard also includes equations for equivalent demand forced outage rate ($EFOR_d$), newly identified outage states, discussion of commercial availability, energy weighted equations for group performance indexes, definitions of outside management control (OMC), pooling methodologies, and time-based calculations for group performance indexes.

1.2 Purpose

This standard is intended to aid the electric power industry in reporting and evaluating electric generating unit reliability, availability, and productivity. It was originally developed to overcome difficulties in the interpretation of electric generating unit performance data from various systems and to facilitate comparisons among different systems. The standard also makes possible the exchange of meaningful data among systems in North America and throughout the world.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

None

3. Definitions

This clause provides the conceptual definitions of the basic performance indexes while the equations to calculate the indexes are included in Clause 8 or Clause 10. The specific subclause in Clause 8 or Clause 10 is referenced for each defined term.

3.1 availability factor (AF): The fraction of a given operating period in which a generating unit is available without any outages.

NOTE—See 8.6.

3.2 demand forced outage rate (FOR_d): A measure of the probability that a generating unit will not be available due to forced outages when there is demand on the unit to generate.

NOTE—See 8.16.2.

3.3 derating adjusted utilization forced outage probability (DAUFOP): A measure of the probability that a generating unit will not be available when needed (derating included).

NOTE—See 8.17.3.

3.4 equivalent availability factor (EAF): The fraction of a given operating period in which a generating unit is available without any outages and equipment or seasonal deratings.

NOTE—See 8.11.

3.5 equivalent availability factor excluding seasonal deratings (EAF_{xs}): The fraction of a given operating period in which a generating unit is available without any outages and equipment deratings.

NOTE—See 8.11.1.

3.6 equivalent forced outage factor (EFOF): The fraction of a given operating period in which a generating unit is not available due to forced outages and deratings.

NOTE—See 8.20.

3.7 equivalent forced outage rate (EFOR): A measure of the probability that a generating unit will not be available due to forced outages or forced deratings.

NOTE—See 8.17.

3.8 equivalent demand forced outage rate (EFOR_d): A measure of the probability that a generating unit will not be available due to forced outages or forced deratings when there is demand on the unit to generate.

NOTE—See 8.17.2.

3.9 equivalent forced outage rate total—generating or other functions (EFOR_T): A measure of the probability that a generating unit will not be available due to forced outages or forced deratings including the exposure to nongenerating functions.

NOTE—See 8.17.1.

3.10 equivalent maintenance outage factor (EMOF): The fraction of a given operating period in which a generating unit is not available due to maintenance outages and maintenance deratings.

NOTE—See 8.21.

3.11 equivalent planned outage factor (EPOF): The fraction of a given operating period in which a generating unit is not available due to planned outages and planned deratings.

NOTE—See 8.18.

3.12 equivalent unavailability factor (EUF): The fraction of a given operating period in which a generating unit is not available due to outages and deratings.

NOTE—See 8.10.

3.13 equivalent unplanned outage factor (EUOF): The fraction of a given operating period in which a generating unit is not available due to forced and maintenance outages and forced and maintenance deratings.

NOTE—See 8.19.

3.14 forced outage factor (FOF): The fraction of a given operating period in which a generating unit is not available due to forced outages.

NOTE—See 8.3.

3.15 forced outage rate (FOR): A measure of the probability that a generating unit will not be available due to forced outages.

NOTE—See 8.16.

3.16 forced outage rate total (FOR_T): A measure of the probability that a generating unit will not be available due to forced outages including the exposure to nongenerating functions.

NOTE—See 8.16.1.

3.17 gross capacity factor (GCF): The gross energy that was produced by a generating unit in a given period as a fraction of the gross maximum generation (GMG). GMG is the period hours (PH) times the gross maximum capacity (GMC).

NOTE—See 8.12.

3.18 gross output factor (GOF): Gross capacity factor (GCF) when the period is applicable only to the in-service state.

NOTE—See 8.14.

3.19 maintenance outage factor (MOF): The fraction of a given operating period in which a generating unit is not available due to maintenance outages.

NOTE—See 8.4.

3.20 net capacity factor (NCF): The net energy that was produced by a generating unit in a given period as a fraction of the net maximum generation (NMG). NMG is the period hours (PH) times the net maximum capacity (NMC).

NOTE—See 8.13.

3.21 net output factor (NOF): Net capacity factor (NCF) when the period is applicable only to the in-service state.

NOTE—See 8.15.

3.22 planned outage factor (POF): The fraction of a given operating period in which a generating unit is not available due to planned outages.

NOTE—See 8.1.

3.23 starting reliability (SR): A measure of the probability that a generating unit will start successfully when required.

NOTE—See 8.24.

3.24 unavailability factor (UF): The fraction of a given operating period in which a generating unit is not available due to outages.

NOTE—See 8.5.

3.25 utilization forced outage probability (UFOP): A measure of the probability that a generating unit will not be available due to forced outages when there is demand on the unit to generate.

NOTE—See 8.16.3. UFOP is the same as demand forced outage rate (FOR_d) (see 3.2); however, UFOP is used in Canada.

3.26 unplanned outage factor (UOF): The fraction of period a generating unit is not available due to unplanned outages.

NOTE—See 8.2.

3.27 weighted availability factor (WAF): The capacity weighted availability factor for a fleet of units. *See: availability factor (AF).*

NOTE—See 10.6.

3.28 weighted demand forced outage rate ($WFOR_d$): The capacity weighted demand forced outage rate for a fleet of units. *See: demand forced outage rate (FOR_d).*

NOTE—See 10.16.2.

3.29 weighted derating adjusted utilization forced outage probability (WDAUFOP): The capacity weighted derating adjusted utilization forced outage probability for a fleet of units. *See: derating adjusted utilization forced outage probability (DAUFOP).*

NOTE—See 10.17.3.

3.30 weighted equivalent availability factor (WEAF): The capacity weighted equivalent availability factor for a fleet of units. *See: equivalent availability factor (EAF).*

NOTE—See 10.11.

3.31 weighted equivalent availability factor excluding seasonal deratings (WEAF_{xs}): The capacity weighted equivalent availability factor excluding seasonal deratings for a fleet of units. *See: equivalent availability factor excluding seasonal deratings (EAF_{xs}).*

NOTE—See 10.11.1.

3.32 weighted equivalent forced outage factor (WEFOF): The capacity weighted equivalent forced outage factor for a fleet of units. *See: equivalent forced outage factor (EFOF).*

NOTE—See 10.20.

3.33 weighted equivalent forced outage rate (WEFOR): The capacity weighted equivalent forced outage rate for a fleet of units. *See: equivalent forced outage rate (EFOR).*

NOTE—See 10.17.

3.34 weighted equivalent demand forced outage rate (WEFOR_d): The capacity weighted equivalent demand forced outage rate for a fleet of units. *See: equivalent demand forced outage rate (EFOR_d).*

NOTE—See 10.17.2.

3.35 weighted equivalent forced outage rate total—generating or other functions (WEFOR_T): The capacity weighted equivalent forced outage rate total—generating or other functions for a fleet of units. *See: equivalent forced outage rate total—generating or other functions (EFOR_T).*

NOTE—See 10.17.1.

3.36 weighted equivalent maintenance outage factor (WEMOF): The capacity weighted equivalent maintenance outage factor for a fleet of units. *See: equivalent maintenance outage factor (EMOF).*

NOTE—See 10.21.

3.37 weighted equivalent planned outage factor (WEPOF): The capacity weighted equivalent planned outage factor for a fleet of units. *See: equivalent planned outage factor (EPOF).*

NOTE—See 10.18.

3.38 weighted equivalent unavailability factor (WEUF): The capacity weighted equivalent unavailability factor for a fleet of units. *See: equivalent unavailability factor (EUF).*

NOTE—See 10.10.

3.39 weighted equivalent unplanned outage factor (WEUOF): The capacity weighted equivalent unplanned outage factor for a fleet of units. *See: equivalent unplanned outage factor (EUOF).*

NOTE—See 10.19.

3.40 weighted forced outage factor (WFOF): The capacity weighted forced outage factor for a fleet of units. *See: forced outage factor (FOF).*

NOTE—See 10.3.

3.41 weighted forced outage rate (WFOR): The capacity weighted forced outage rate for a fleet of units. *See: forced outage rate (FOR).*

NOTE—See 10.16.

3.42 weighted forced outage rate total—generating or other functions (WFOR_T): The capacity weighted forced outage rate total—generating or other functions for a fleet of units. *See: forced outage rate total—generating or other functions (FOR_T).*

NOTE—See 10.16.1.

3.43 weighted maintenance outage factor (WMOF): The capacity weighted maintenance outage factor for a fleet of units. *See: maintenance outage factor (MOF).*

NOTE—See 10.4.

3.44 weighted planned outage factor (WPOF): The capacity weighted planned outage factor for a fleet of units. *See: planned outage factor (POF).*

NOTE—See 10.1.

3.45 weighted unavailability factor (WUF): The capacity weighted unavailability factor for a fleet of units. *See: unavailability factor (UF).*

NOTE—See 10.5.

3.46 weighted utilization forced outage probability (WUFOP): The capacity weighted utilization forced outage probability for a fleet of units. *See: utilization forced outage probability (UFOP).*

NOTE—See 10.16.3.

3.47 weighted unplanned outage factor (WUOF): The capacity weighted unplanned outage factor for a fleet of units. *See: unplanned outage factor (UOF).*

NOTE—See 10.2.

4. Unit states

A unit state is a particular unit condition that is important for collecting data on performance.

NOTE—The state definitions are related as shown in Figure 1. The transitions between states are described in Annex B.

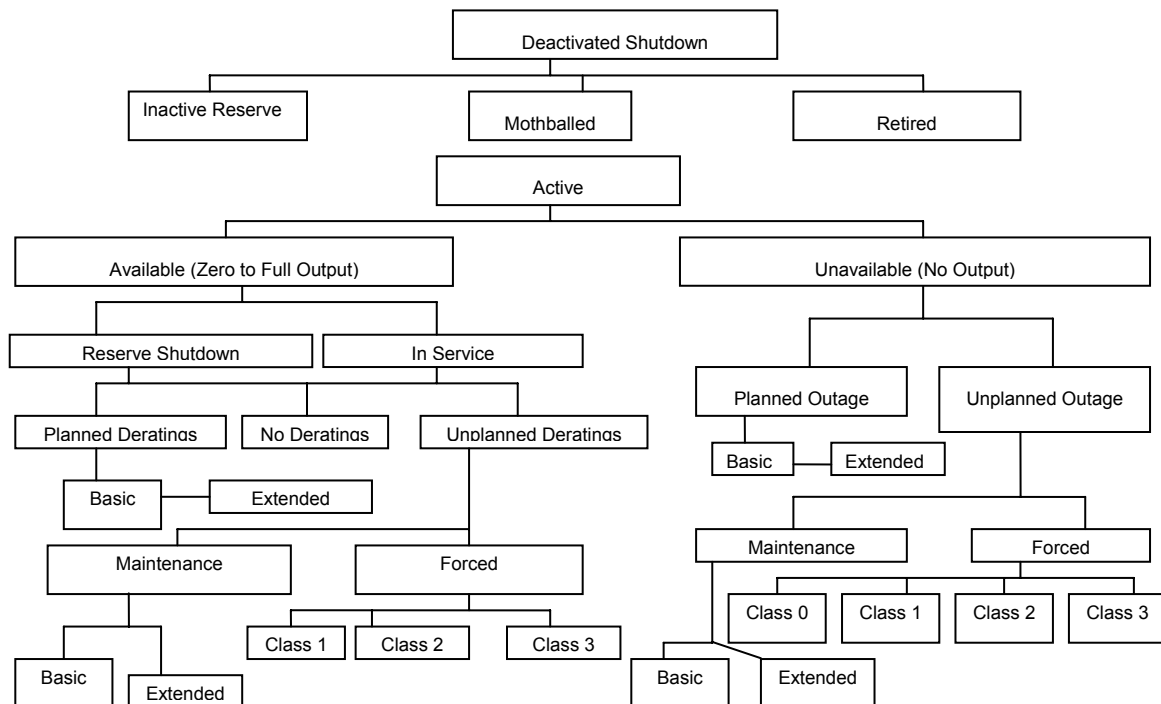


Figure 1—Relation between unit states

4.1 Active

The active state is where a unit is in the population of units being reported.

NOTE—A unit initially enters the active state on its service date and leaves the active state on a deactivation date.

4.1.1 Available

The available state is where a unit is capable of providing service, regardless of whether it is actually in service and regardless of the capacity level that can be provided.

4.1.1.1 In service

The in-service state is where a unit is electrically connected to the system and performing generation function.

4.1.1.1.1 In-service nongenerating mode

The in-service nongenerating mode state is where a unit is electrically connected to the system and performing nongenerating functions.

NOTE 1—Certain types of units may be performing functions other than generating while being in service and exposed to failure: A pumped storage unit can be in pumping mode, an electrochemical energy storage unit (battery) can be in charging mode, and a combustion turbine or a hydro unit can be in synchronous condensing mode.

NOTE 2—Certain types of generating units may be kept on line at minimum output when there is no demand on the unit to reduce the number of starts.

4.1.1.2 Reserve shutdown

The reserve shutdown state is where a unit is available, but not in service.

NOTE—This state is sometimes referred to as *economy shutdown*.

4.1.2 Unavailable

The unavailable state is where a unit is not capable of operation because of operational or equipment failures, external restrictions (as defined in Annex D), testing, work being performed, or an adverse condition. The unavailable state persists until the unit is made available for operation, either by being synchronized to the system (in-service state) or by being placed in the reserve shutdown state.

4.1.2.1 Planned outage

The planned outage state is where a unit is unavailable due to inspection, testing, nuclear refueling, or overhaul. A planned outage is scheduled well in advance.

4.1.2.1.1 Basic planned outage

The basic planned outage state is the planned outage as originally scheduled and with a predetermined duration.

4.1.2.1.2 Extended planned outage

The extended planned outage state is the extension of the basic planned outage beyond its predetermined duration.

NOTE—Extended planned outage applies only when planned work exceeds predetermined duration. The extension, due to a condition discovered during the planned outage that forces the extension of the planned outage, is classified as a Class 1 unplanned outage (see 4.1.2.2.1.2). A startup failure would result in a Class 0 unplanned outage (see 4.1.2.2.1.1)

4.1.2.2 Unplanned outage

The unplanned outage state is where a unit is unavailable, but is not in the planned outage state.

NOTE 1—When an unplanned outage is initiated, the outage is classified according to one of five classes, as defined in 4.1.2.2.1.1 through 4.1.2.2.1.4 and 4.1.2.2.2.1 and 4.1.2.2.2.2. A Class 0 unplanned outage applies to a startup failure, and Class 1 applies to a condition requiring immediate outage. Also, an unplanned outage starts when a planned outage ends, but is extended due to unplanned work. Class 2, Class 3, and maintenance outage apply to outages where some delay is possible in removing the unit from service. The class (2, 3, or maintenance) of outage is determined by the amount of delay that can be exercised in the removal of the unit. The class of outage is not made more urgent if the time of removal is advanced due to favorable conditions of system reserves or availability of replacement capacity for the predicted duration of the outage. However, an unplanned outage starts when the unit is removed from service or is declared unavailable when it is not in service.

NOTE 2—During the time the unit is in the unplanned outage state, the outage class is determined by the outage class that initiates the state.

NOTE 3—In some cases, the opportunity exists during unplanned outages to perform some of the repairs or maintenance that would have been performed during the next planned outage. If the additional work extends the outage beyond that required for the unplanned outage, the remaining outage should be reported as a planned outage.

4.1.2.2.1 Forced outage

A forced outage cannot be deferred beyond the end of the next weekend.

4.1.2.2.1.1 Class 0 unplanned outage (starting failure)

A Class 0 unplanned outage results from the unsuccessful attempt to place the unit in service (see 4.1.3.1).

4.1.2.2.1.2 Class 1 unplanned outage (immediate)

A Class 1 unplanned outage requires immediate removal from the existing state.

NOTE—A Class 1 unplanned outage can be initiated from either the in-service state or reserve shutdown state. A Class 1 unplanned outage can also be initiated from the planned outage state. See the note in 4.1.2.1.2.

4.1.2.2.1.3 Class 2 unplanned outage (delayed)

A Class 2 unplanned outage does not require immediate removal from the in-service state, but requires removal within 6 h.

4.1.2.2.1.4 Class 3 unplanned outage (postponed)

A Class 3 unplanned outage can be postponed beyond 6 h, but requires that a unit be removed from the in-service state before the end of the next weekend.

NOTE—Class 2 and Class 3 can be initiated only from the in-service state.

4.1.2.2.2 Maintenance outage

A maintenance outage can be deferred beyond the end of the next weekend, but requires that a unit be removed from the available state or another unplanned outage state before the next planned outage.

4.1.2.2.2.1 Basic maintenance outage

The basic maintenance outage state is the maintenance outage as originally anticipated, and it may or may not be of a predetermined duration.

4.1.2.2.2.2 Extended maintenance outage

The extended maintenance outage state is the extension of the basic maintenance outage beyond its anticipated duration.

NOTE—Extended maintenance outage applies only when the maintenance work exceeds anticipated duration. The extension, due to a condition discovered during the maintenance outage that forces the extension of the maintenance outage, is classified as a Class 1 unplanned outage (see 4.1.2.2.1.2). A startup failure would result in a Class 0 unplanned outage (see 4.1.2.2.1.1).

4.1.3 Unit starts

4.1.3.1 Attempted unit start

An attempted unit start is the action to bring a unit from shutdown to the in-service state. Repeated initiations of the starting sequence without accomplishing corrective repairs are counted as a single attempt.

4.1.3.2 Starting failure

Starting failure is the inability to bring a unit from some unavailable state or reserve shutdown state to the in-service state within a specified period. The specified period may be different for individual units. Repeated failures within the specified starting period are counted as a single starting failure.

4.1.3.3 Actual unit start

The actual unit state is the occurrence of bringing a unit from some unavailable state or the reserve shutdown state to the in-service state within a specified period. The specified period may be different for individual units.

4.2 Deactivated shutdown

The deactivated shutdown state is where a unit is unavailable for service for an extended period of time for reasons not related to the equipment.

4.2.1 Inactive reserve

The inactive reserve state is where a unit is unavailable for service, but can be brought back into service in a relatively short period of time, typically measured in days.

4.2.2 Mothballed

The mothballed state is where a unit is unavailable for service, but can be brought back into service with appropriate amount of notification, typically weeks or months.

4.2.3 Retired

The retired state is where a unit is unavailable for service and not expected to return to service in the future.